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NOTES ON A CALIFORNIA EARTHWORM, PLUTELLUS PAPILLIFER (EISEN, 1893)*

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The genus *Plutellus* Perrier, 1873, comprises species from Pennsylvania, Guatemala, the western coast of the United States, Queen Charlotte Island, Australia, Tasmania, New Caledonia, Auckland Islands, Burma, India and Ceylon. Such a distribution, in view of the "polyphyly" so prevalent in the Megascolecidæ, is sufficient reason for suspicion that *Plutellus* may also be an aggregation of species that should be split into morphologically homogeneous, "monophyletic" genera of a more orthodox nature. Such a revision, if necessary, is impossible at present as most if not all of the species are inadequately characterized.

Four species have been erected for Californian forms. Each species, except for notes of uncertain value on the penial setæ of two forms, is known only from the original descriptions. Types of three of the species were destroyed at the time of the earthquake in 1906. One or more specimens of two of these species, identified by the author (Eisen), may be in the Hamburg Museum which has the immature types of the fourth species. Type localities of three species are undesignated. As a result of mistakes or omissions in earlier accounts

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and lack of information as to variation in characteristics of taxonomic importance none of the Californian species can be adequately defined at present.

The worms which provided the material for this article are from a small collection forwarded by Dr. A. W. Herre of Stanford University. In addition to the Plutelli described below, this collection comprises a number of unidentifiable juveniles, ten clitellate specimens of *Allobophora caliginosa* f. *trapezoides* (Savigny) 1826, and one clitellate specimen of *Octolasium lacteum* Örley 1881. The author's thanks are extended to Dr. Herre for the collection, preservation in good condition and forwarding of the specimens.

Plutellus papillifer (Eisen) 1893

Argilophilus marmoratus papillifer Eisen, Zoe, IV, 1893, p. 253. (No types. Type locality not designated. Berkeley, San Francisco, Monterey, Palo Alto, San Joaquin Valley.)

Argilophilus marmoratus papillifer, Eisen, Mem. California Acad. Sci., II, (3), 1894, p. 55. (South of San Francisco Bay; Santa Rosa, Santa Clara, Monterey, Fresno and Nevada counties.)

Megascolides papillifer, Beddard, Monog. 1895, p. 495.

Plutellus papillifer, Michælsen, Das Tierreich X, 1900, p. 166.

Plutellus papillifer, Michælsen, Ark. Zool. XIII, (19), 1921, p. 11. (Notes on penial setæ of a specimen from Oakland identified by Eisen. One or more specimens identified by Eisen may be in the Hamburg Museum.)

Material examined. Two juvenile and one clitellate specimens labelled, "In loam, Mt. McPherson, Castle Rock Ridge, Santa Cruz Mts., Santa Cruz Co., Calif. Elevation 3100 feet. January 14, 1939. Coll. Albert W. Herre."

One clitellate specimen labelled, "On wooded slopes in forest above Woodside, San Mateo Co., Calif. Elevation about 1,000 feet. May, 1939. Coll. Albert W. Herre.".

Three clitellate specimens labelled, "In soil, rather sandy loam. Mt. McPherson, Castle Rock Ridge, Santa Cruz Mts., Santa Cruz Co., Calif. Elevation 3,100 feet. March 4, 1939. Coll. Albert W. Herre."

External characteristics. Length 85–155 mm. Diameter four to six mm. Unpigmented (formalin preservation), clitellar colouration reddish. The prostomium is epilobous but with no transverse furrow at the posterior end of the tongue.

Setæ begin on ii, on which all four couples are present. On segments just behind the clitellum *ab ca.* = ½ *bc*, *bc* and *aa ca.* = both *bc* and *aa* a trifle smaller than *cd*, posteriorly *dd* < ½*C*. Setæ, at least in the preclitellar segments, are ornamented ectally with numerous, fairly closely crowded, transversely placed rows of fine teeth. Setal lines (longitudinal) are only slightly, if at all, dislocated mesially on clitellar segments.

Nephropores begin on ii and are variable in position, located on anterior segments of certain specimens as follows: ii–x and xii–xiii on *d*, xiv on *c;* ii–vi on *d*, vii–viii on *c;* vii on *c*, viii on *d*–left, on

c–right, ix on *d*–left, on *c*–right, x–xii on *c*, xiii on *d*–left, on *c*–right, xiv on *c*–left, on *d*–right.

The clitellum is saddle-shaped, extending from 12/13 to 18/19 or slightly onto xix and ventrally to or almost to *b;* sites of intersegmental furrows slightly indicated, dorsal pores lacking, setæ present. The clitellum may be constricted (clitellar segments slightly narrower than pre- and postclitellar segments) or slightly protuberant, the colouration very faint, faint or marked.

Dorsal pores are small, recognizable only with difficulty on the postclitellar portion of the body, beginning on 18/19 (1) or 19/20 (2).

Spermathecal pores are present on one worm only, and are rather small, transversely placed, shortly elliptical apertures with centres on *b*, each aperture filled with a translucent material. Each pore is located at or near the centre of a sharply demarcated, transversely placed, tumescent area of approximately elliptical outline, intersegmental furrows 7/8 and 8/9 lacking on the tumescences, pores on approximate sites of and in line with the furrows.

Female pores are minute, on or just median to *a*, about midway between the setal arc and 13/14.

Male pores are minute, longitudinally placed, straight or crescentic slits (in the latter case with concave side mesially) on *b* of *xviii*. Appertures of *a* follicles of xviii are dislocated laterally, of *b* follicles mesially, the male pores closer to the apertures of the *b* follicles than the apertures of the follicles are to each other, the sites of male pores not readily recognizable and apertures visible only with slight traction on neighbouring epidermis under best optical conditions. Male pores and apertures of penisetal follicles are located on paired, transversely placed, indistinctly demarcated areas of approximately elliptical outline, extending from just median to *a* slightly into *bc*, the surface convex, each porophore apparently restricted to a middle, secondary annulus (if the usual two, secondary furrows were present). The porophores are connected on one specimen only by a transverse, midsegmental ridge, apparently the result of some special contraction, as there is no trace of any such ridge or of epidermal thickening in *aa* of other worms. Immediately anterior and posterior to each porophore is a transversely placed area of thickly crescentic outline, the concave sides facing the male porophore. These lunate areas may be opaque, sharply demarcated and tumescent, or depressed, greyish translucent and indistinctly demarcated, reaching slightly further mesially and laterally than the male porophores, and possibly extending slightly onto xvii and xix (in some specimens with an appearance of dislocating anteriorly or posteriorly 17/18 and 18/19, though the furrows are lacking in *ab*).

Genital markings are unpaired, median, transversely placed areas of shortly elliptical to shortly spindle-shaped outline, in *aa*, reaching laterally on each side halfway to *a* or slightly less. Markings may be tumescent, rather conspicuously protuberant and sharply demarcated as on aclitellate specimens, or indistinctly demarcated and

depressed. In the former condition each marking has a wide, opaque, marginal band and a greyish, translucent, central area.

GENITAL MARKINGS

Specimen	*Intersegmental furrow*													*Locality*
	9/10	10/11	11/12	12/13	13/14	14/15	15/16	16/17	17/18	18/19	19/20	20/21	21/22	
1	+	+	+	+	−	+	−	+	−	−	+	+	−	Mt. McPherson
2	+	+	+	+	−	+	+	+	−	−	+	+	−	"
3	+	+	−	−	−	+	−	−	−	−	+	+	−	"
4	+	+	+	−	−	+	+	+	−	−	+	+	+	Woodside
5	+	+	+	+	−	+	−	+	−	−	+	+	−	Mt. McPherson
6	+	+	+	+	−	+	+	+	−	−	+	+	−	"
7	+	+	+	+	−	+	+	+	−	−	+	+	−	"

Internal anatomy.—Septum 5/6 is very delicate and transparent; 6/7 slightly muscular; 7/8–10/11 thickly muscular, 11/12–13/14 muscular; 14/15–16/17 with muscular fibres but quite translucent; 5/6–10/11 or 11/12 funnel-shaped with apices posteriorly.

The large gizzard is in v (7), 6/7 attached to the gut quite definitely behind the gizzard. Septum 5/6 passes to the anterior margin of gizzard, but is not adherent there, and with care can be lifted off to a region of attachment at or just behind the posterior margin of the gizzard. In vi–ix the œsophagus is narrow and white, in x–xiv widened and dark brown, except for a white, median band on the ventral face that is slightly narrowed posteriorly, in xv–xvi brown ventrally as well as dorsally and laterally, the ventral wall of the gut quite obviously thicker than the dorsal wall. The inner face of the gut in x–xiv is provided with numerous, closely crowded, rather irregular, longitudinally placed, slightly lamelliform, white ridges. Midventrally the floor of the gut in this region is raised to form a rather conspicuous and fairly wide ridge which may have a smooth flat surface, or a longitudinally placed groove of variable depth. In one worm the margins of the groove are dark red. The narrow, white, œsophageal valve is anteriorly in xvii, with straight, longitudinal ridges on the inner wall (4 specimens, unrecognizable because of distention in 3). The intestine begins posteriorly in xvii (4).

Septum 17/18 is attached to the intestines slightly behind the origin, and cannot be dissected off anteriorly. The typhlosole, which begins in xxvii (5), is a slightly zigzagged, lamelliform ridge, very gradually decreasing in height posteriorly and unrecognizable behind cxviii (in worm with 164 segments, mm. 82 of length 105), or cxix (in worm with 162 segments, mm. 122 of length 155). In one worm a short, anterior portion of the typhlosole is slightly thickened, with numerous, small, vertically placed, buttress-like ridges on the lateral faces so that the typhlosole has an appearance of being triangular in cross section. From xxvii to lii (5) on the floor of the gut at the mid-ventral line there is a longitudinally placed groove. The margins of the groove may be rather conspicuously raised to form two, longitudinal ridges. Calciferous glands, cæca and supra-intestinal glands are lacking.

The dorsal blood vessel (single) extends anteriorly to and apparently into the pharyngeal bulb. A supra-œsophageal trunk is probably present in x–xiii and adherent to the gut, but is usually empty, in one specimen distended with blood only in xiii where it bifurcates posteriorly, each branch passing laterally to a heart. Extra-œsophageal trunks are formed anteriorly (in iv or v?) by the union of vessels from the pharyngeal bulb and a vessel on the parietes that is parallel but slightly lateral to the nerve cord. Posteriorly in xi or xii each extra-œsophageal turns mesially onto ventral face of the gut and disappears close to the median line. The ventral trunk bifurcates at the anterior margin of the subpharyngeal ganglia. Lateroparietal trunks were not found, and a subneural trunk is lacking (5). Hearts of x–xiii bifurcate dorsally, one branch passing to the dorsal vessel and the other to the supra-œsophageal. Commissures of ix open only into the dorsal trunk. Commissures from the dorsal trunk are present in vi–viii, but have not been traced to the ventral trunk, commissures and hearts of ix–xiii passing into the ventral trunk. The last pair of hearts is in xiii (7). No hearts or commissures have been found in xiv (7).

Nephridia are transversely placed loops in the anterior portions of the segments, extending from *a* to or nearly to *d*. Nephrostomes are small and rounded, close to the ventral parietes in region of *b*. Nephridia are present in xviii though crowded between the loops of the prostate.

Male funnels are present in x and xi, in clitellate specimens with slight or fairly marked spermatozoal iridescence. Seminal vesicles are paired in xi and xii, vertically placed, on the posterior faces of 10/11 and 11/12 reaching upwards to or nearly to the dorsal vessel, but ventrally not to the parietes. In x and xi beneath the gut there is compacted coagulum in clitellate worms, but testis sacs have not been found in either segment, nor seminal vesicles in x. Prostates are confined to xviii, but bulge 17/18 anteriorly and 18/19 posteriorly. The prostatic duct is 1½–2 mm. long, with muscular sheen, slightly thickened ectally, curved once entally to produce a J-shape.

The deferent ducts of a side pass simultaneously into an ectal portion of the prostate gland, definitely ental to the duct.

Two penisetal follicles are present on each side, bound together entally, diverging ectally, the lateral follicle passing into the parietes on the posterior face of the prostatic duct. Each follicle contains one seta. There are no marked differences between setæ of *a* and *b* follicles. The setal shaft is slightly arced, or may be nearly straight, except for slight curves near ectal and ental ends, both curves on the same side of the shaft, the tip rounded. Ornamentation is of somewhat irregular, transversely placed rows of fine spines, an occasional spine slightly widened entally and triangular. There are no enlarged spines or teeth towards the ectal end of the ornamented region.

MEASUREMENTS OF PENIAL SETAE

Seta	*Length*	*Thickness*	*Extent of ornamentation*
a	1.23	0.06	0.35
b	1.22	0.04	0.31
a	1.15	0.05	0.32
b	1.15	0.05	0.38
a	1.14	0.04	0.30
b	1.15	0.045	0.35
a	1.12	0.042	0.28
b	1.15	0.05	0.27

Length is measured along line ab in fig. 1.
Thickness is measured at region of greatest width at or near base.
Extent of ornamentation is measured along line cd in the figure.
The first four setæ are from one specimen, the other four from another worm.

Spermathecæ are large, reaching dorsally into contact with the parietes, all four spermathecæ of the thecal worm of about the same size. The duct is not slender, shorter than, and clearly marked off from the ampulla, with one slight bend, abruptly narrowed within the parietes. In the narrowed parietal portion the lumen is small and almost circular in section, this passage opening into the wider, ental portion of the lumen through a small papilla, which forms nearly all of the floor of an ental chamber. In this chamber the lumen is irregularly elliptical to almost circular in cross section.

The longitudinal musculature is uninterrupted over the sites of genital markings which are areas of epidermal thickening.

Remarks. Nephropores are occasionally visible on clitellar segments, on *c* or *d*, but have not been recognized with certainty on postclitellar segments. As all specimens are more or less strongly contracted a different method of killing and fixing is probably re-

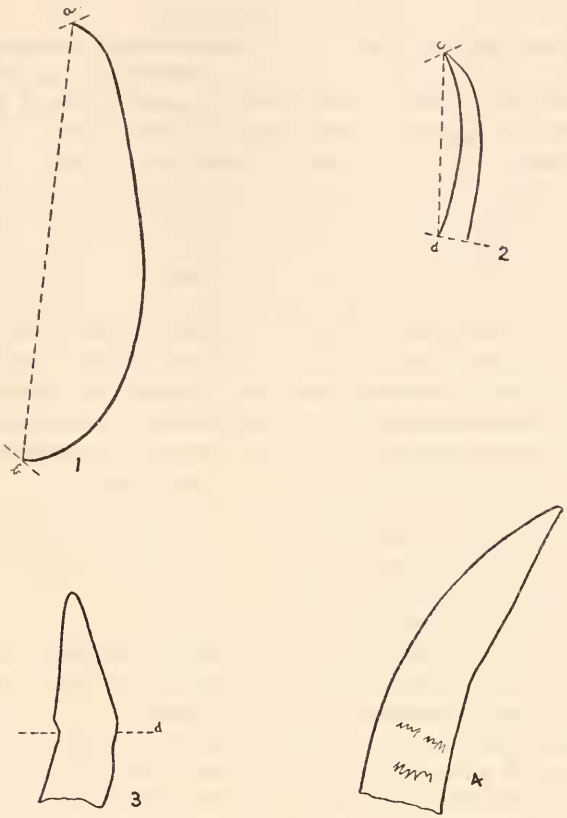

Fig. 1. Isolated penial seta of *Plutellus papillifer* (Eisen). Length is measured along dotted line *ab*.

Fig. 2. Ectal portion of penial seta of same. Extent of ornamentation is measured along dotted line *cd*, *d* indicating the level where ornamentation ends. The ornamentation begins at various levels from just behind the spear-head-shaped portion.

Fig. 3. Tip of a penial seta of same. × *ca.* 325. Ornamentation begins at *d*.

Fig. 4. Tip of a penial seta of same. × *ca.* 325. Dotted line indicates level where ornamentation begins. All figures are camera lucida sketches.

quired to provide satisfactory material for study of the nephropores and dorsal pores.

Spermathecal pores are lacking on six specimens, a grey spot recognizable in the epidermis at the site of each spermathecal pore, but even with best optical conditions no perforation visible. In each of the six specimens, on the coelomic face of the parietes over approximate site of each spermathecal pore, there is a tiny, rounded body, presumably the rudiment of a spermatheca, the rudiments of

about the same size in juvenile and clitellate worms. An athecal condition found more or less frequently in certain species of Oriental earthworms is thought to be due to inhibition of development, resulting from activities of parasites in juvenile stages prior to the period when the spermathecæ begin to form, while complete or incomplete batteries of deformed or rudimentary spermathecæ, less frequently found, are the result of parasitic activity at a later stage. Some such parasitic activity may have been responsible for the rudimentary condition of the spermathecæ in the specimens of *papillifer* as iridescence on the male funnel is produced by the presence of ripe spermatozoa, thus indicating a stage of maturity at which full development of all sex organs might be expected. No parasites have been observed in the California worms, and the masses of gregarines so often associated with inhibition or abnormal development of spermathecæ in the Oriental worms are absent. There is of course another possibility, that spermathecæ develop very rapidly after other sexual organs have matured.

On the anterior faces of 6/7–9/10, on each side and just median to the vascular commissure, there is a fairly conspicuous but thin, flat band of white tissue with frayed margins, the band curved into an arc like that of the commissure.

Two subspecies, *ornatus* and *papillifer*, were recognized by Eisen, who was unable to find internal differences between worms with paired and unpaired genital papillæ. Michælsen after examination of penial setæ of specimens, obtained from Eisen, of *ornatus* and *papillifer* raised the latter to specific status, but omitted reference to other internal structures. As there are contradictions in Eisen's account of the internal anatomy of *marmoratus* there may be internal differences of taxonomic importance—note for instance (1894, p. 41) "Dorsal and ventral vessels connected by five pairs of hearts in xiv to x.", and (p. 53) "Three pair of stout, oblong, thrice-contracted and sac-like hearts connect the ventral and dorsal vessels in x, xi, and xii.". Neither of these characterizations is applicable to the forms described above, which may indicate failure to recognize a third species, though presence of hearts in xiv would be most unusual for a Megascolecid.

Absence of large teeth near ectal end of the penial shaft seems to be characteristic and may provide further evidence, in addition to differences in genital markings,[1] for specific distinctness from *marmoratus* as well as *collinus*. This latter species is dubious and, aside from the difference in penial setæ, cannot be distinguished at present from *papillifer*. *P. sierræ* Michælsen 1921 (erected on two juvenile and one aclitellate specimens) can be distinguished at present from

[1] Eisen (1894, p. 53 and p. 55) mentions having had one specimen of *marmoratus* with unpaired, median genital markings and one specimen of *papillifer* with paired markings. As Eisen differentiated *marmoratus* and *papillifer* from each other only by the paired or unpaired condition of the genital markings, the sole criterion for identification of these exceptional specimens was geographic.

papillifer only by the absence of genital markings,—the "quere ventralmediane Pubertätspolster", probably of no taxonomic importance as a similar appearance characterizes one of Herre's specimens. Absence of genital markings may not be a valid criterion for specific status, as an occasional specimen of a species with genital markings may fail to develop the markings. Dimensions and ornamentation of penial setæ of *P. sierræ* are similar to those of setæ from Herre's specimens of *papillifer*, while penial setæ of Michælsen's specimen of *papillifer* are longer, slenderer, and (judging from the figure) with a distinctly different type of ornamentation. In absence however of information as to the method of measurement of length little importance can be attributed at present to size differences.

Because of the uncertainty with regard to several characteristics that may be of taxonomic value in connection with the problem of differentiating Californian species it is impossible to give a definitive diagnosis of *papillifer*, or even to be sure that *papillifer* is the correct name for the specimens described above. The subjoined diagnosis, based on Herre's specimens, can be regarded only as tentative. To fix the species, worms from one of Eisen's original *papillifer* localities must be adequately characterized and designated as a Neotype and Neoparatypes. Such specimens should be preserved in the best possible condition, and deposited in some museum or museums where they will be available for study.

Californian species of *Plutellus* as a group are distinguished from Guatemalan and Oregon species by spermathecal characteristics, from the Guatemalan species by the quadrithecal condition, and from the Oregon species by the adiverticulate spermathecæ.

Diagnosis. Quadrithecal; spermathecal pores on or close to sites of 7/8–8/9, on *b*, on or close to centres of transversely placed porophores. Male pores minute, longitudinally placed slits on *b*, each pore together with apertures of penisetal follicles on an indistinctly demarcated, transverse porophore with convex surface; apertures of penisetal follicles dislocated into *ab*, apertures of *b* follicles closer to male pores than to those of *a* follicles. Genital markings unpaired, median, transversely placed areas of epidermal thickening, in middle half of *aa*, on 9/10–10/11, 14/15, and 19/20–20/21; a transversely placed, broadly crescent-shaped marking immediately anterior and posterior to each male porophore. Female pores paired, on or close to *a*. First dorsal pore on 18/19–19/20. Clitellum saddle-shaped, on xiii–xviii and ventrally to *b*. Nephropores on *c* or *d* (only?). Setæ: *ab ca.* = ½*bc*, *bc ca.* = *aa* slightly < *cd*, *dd* < ½C. Prostomium epilobous. Unpigmented. Length 85–155 mm. Diameter 4–6 mm.

Gizzard in v. Intestine begins in xvii. Typhlosole lamelliform, small, in xxvii : : cxviii–cxix. Last hearts in xiii. Holandric; seminal vesicles in xi and xii. Vas deferens passes into ectal portion of prostate gland. Spermathecal duct shorter than the ampulla, lumen in ental chamber opening through an ectal papilla into narrow passage within short, slender, parietal portion. Penial setæ 1.12–1.23 mm. long and 0.042–0.06 mm. thick, shaft slightly arced; ornamentation of transversely placed rows of fine spines, terminating *ca.* 0.27–0.35 mm. from ectal end.

Family Lumbricidae

Genus **Allolobophora** Eisen

Allolobophora caliginosa (Savigny) 1826

f. **trapezoides** (A. Duges)

Material examined. Ten clitellate specimens labelled, "In boggy meadow in soil and under dead limbs from pine trees,—one mile east of Cow Creek Ranger Station, Sonora Pass Road, Tuolumne Co., Calif. Sierra Nevada Mts., altitude about 5,800 feet. July 17, 1939. Coll. Ira L. Wiggins."

Notes. Setæ *a* and *b* are a trifle more closely paired on xv than on xiv or xvi as a result of median displacement of *b*, or lateral displacement of *a*, or both, and are smaller than on xiv and xv, sigmoid. Ventral Setæ of ix–xi are modified. Ventral setæ of xii–xiv are sigmoid, ornamented near tips with transverse rows of very fine teeth. Ventral setæ of xxx and xxxii are also slightly modified, small.

Seminal vesicles of ix–xi contain small brown discs.

Genus **Octolasium** Örley

Octolasium lacteum Örley 1881

Material examined. One clitellate specimen labelled, "In boggy meadow in soil and under dead limbs from pine trees,—one mile east of Cow Creek Ranger Station, Sonora Pass Road, Tuolumne Co., Calif. Sierra Nevada Mts., altitude about 5,800 feet. July 17, 1939. Coll. Ira L. Wiggins."

The *b* setæ of xv are displaced mesially. Tubercles are present in *ab* on xxii. All nephropores, when recognizable, are close to the *b* line.

The typhlosole begins in the region of xix or xx and ends in xc (specimen of 111 segments).